UM10756

EM783 frequently asked questions (FAQ)

Rev. 1.1 — 17 December 2013 **User manual**

Document information

Info	Content
Keywords	EM783, FAQ, Metrology
Abstract	Frequently asked questions on EM783

Revision history

Rev	Date	Description
1.1	20131217	Corrected “EM783 app note” to “EM783 SDK user manual”.
1.0	20131015	Initial version

Contact information

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1. Introduction

EM783 is the next generation e-metering chip with a built-in metrology engine. EM783 is built around a low-power, cost-effective and industry standard ARM Cortex-M0 core. The ARM Cortex-M0 runs with a speed up to 48 MHz and offers 4 kB of EEPROM, 32 kB of flash memory, 8 kB of SRAM and various serial peripherals.

For design flexibility, NXP offers multiple variants of EM783 as single-channel (SC), multi-channel (MC), single-phase (SP) and three-phase (TP). The variant chips are:

- EM783-MC3
- EM783-MC6
- EM783-SC
- EM783-SP
- EM783-TP

The EM783 reference design evaluation module (EVM) includes an SDK package consisting of a reference energy meter application and metrology library in binary format. The metrology library provides the interface to the EM783 metrology engine. The SDK package is available for download from the NXP website.

This document provides details on using EM783 in question and answer format.

1.1 Key applications

- Smart plugs and plug meters
- Single-phase residential meters
- DALI/DMX and KNX nodes with metering functionality
- Industrial sub-meters
- Power monitors for servers
- Smart appliances

1.2 Block diagram

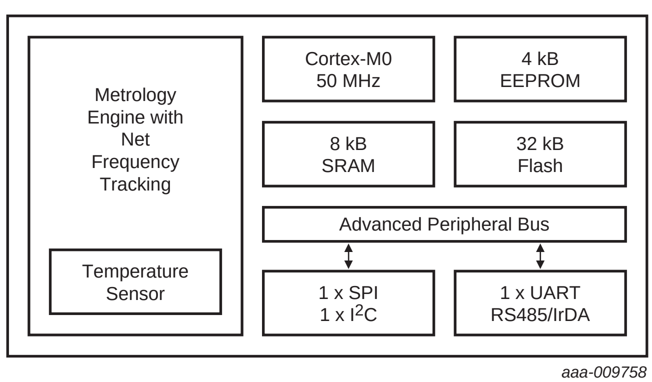
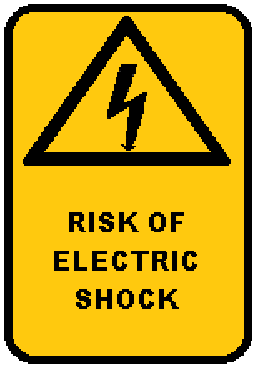


Fig 1. EM783 block diagram

1.3 Disclaimer

The EM783 EVM is a prototype only for demonstration and evaluation purposes.



Improper use of the EVM can result in electrical shock and fire hazard due to the operational voltages and currents of the EVM. Ensure that only qualified personnel familiar with the risks and hazards associated with high voltages and currents handle the EVM. Do not touch the EVM or its components when the EVM is energized.

Fig 2. Caution

1.4 Support information

Use the following link for additional information on EM783:

http://www.nxp.com/products/power_management/energy_measurement_ics/series/EM783.html

Send an email to em7xx.support@nxp.com for technical support on EM783.

2. EM783 frequently asked questions

2.1 EM783 specification

2.1.1 What is the accuracy of EM783?

The table below lists the accuracy of the energy measurements provided by the different variants of the EM783.

Table 1. EM783 Accuracy

Variant	Accuracy (%)	Dynamic range
MC3	1	1000
SC	1	1000
SP	1	1000
MC6	2	50
TP	2	50

2.1.2 What is the accuracy of the frequency measurement?

0.01% is the accuracy of frequency measurement.

2.1.3 What is the range of current that can be measured with EM783?

The analog front end design (AFE) determines the range of current that can be measured using EM783. The AFE scales the input voltage and current signals to a voltage signal in the range from VSS to VDD at EM783 inputs. EM783 samples this signal and provides the metrology data.

2.1.4 Up to which harmonic can EM783 measure?

EM783 can measure up to 64^{th} harmonic.

2.2 Metrology engine software interface

2.2.1 Is the metrology engine software source code available?

No. Metrology engine software for EM783 is provided only in the binary form as a library. The interfaces provided by the metrology engine software and the API call sequence are detailed in EM783_API.pdf. The API document can be downloaded from the EM783 support website.

2.2.2 What are the interfaces provided by the metrology engine software?

Refer to EM783_API.pdf.

2.2.3 How are the initial values computed for the calibration data supplied to the metrology engine software using metrology_ranges_t structure?

The calibration data supplied to the metrology engine software via the metrology_ranges_t structure are:

1. V_{pp}: This parameter represents the maximum peak-to-peak value of the AC voltage signal at the input of the AFE that produces a voltage signal with a peak-to-peak value of VDD at the EM783 input. The value of this parameter depends on the transfer function of the AFE circuitry. Its value is at least:

$$Vpp = V\max * 2 * \sqrt{2} \quad (1)$$

In practice, the circuit design ensures that the maximum peak-to-peak input voltage results only in a peak-to-peak voltage swing between 5% and 95% of VDD at the EM783 input (this is to avoid operating in the non-linear regions of the opamps). Consider the following sample design for 220 V AC mains:

Max input voltage Vmax (RMS): 260 V; VDD: 3.3 V

Maximum peak value of the input voltage: 260 x √2 = 367.7 V.

95% of VDD: 0.95 x 3.3 = 3.135 V

367.7 V peak input AC voltage produces a signal with a peak of 3.135 V at the EM783 input.

Hence, for a peak of 3.3 V at the EM783 input, the peak value of the input voltage must be: (3.3 x 367.7) ÷ 3.135 =387.05 V.

Therefore, the initial value for the range parameter = 2 x 387.05 = 774.1 V.

2. I_{pp}: This parameter represents the maximum peak-to-peak value of the AC current signal at the input of the AFE that produces a voltage signal with a peak-to-peak value of VDD at the EM783 input. The value of this parameter depends on the transfer function of the AFE circuitry.

   The high-gain current channel is designed to measure the current in the range of 0 to (I_{max} ÷ 32). Its value is at least:

$$Ipp(high\_gain) = (I\max/32) * 2 * \sqrt{2} \tag{2}$$

   In practice, the circuit design ensures that the maximum peak-to-peak input voltage results only in a peak-to-peak voltage swing between 5% and 95% of VDD at the EM783 input (this is to avoid operating in the non-linear regions of the opamps). Consider the following sample design:

   a. 220 V AC mains
   b. Max RMS current to be measured, I_{max}: 70 A
   c. Gain of the high-gain channel: 32
   d. VDD: 3.3 V

   Maximum peak value of the input current: 70 / 32 x √2 = 3.09 A.

   95% of VDD: 0.95 x 3.3 = 3.135 V

   3.09 A peak input AC current produces a signal with a peak of 3.135 V at the EM783 input.

   Hence, for a peak of 3.3 V at the EM783 input, the peak value of the input current must be: 3.3 x 3.09 ÷ 3.135 = 3.253 A.

   Therefore, the initial value for the range parameter = 2 x 3.253 = 6.506 A.

   The low-gain current channel is designed to measure a maximum current of $_{Imax}$. Hence, the initial value of the calibration parameter for the low-gain channel is:

   32 x 6.506 = 208.192 A.

3. Delta Phi: This parameter represents the phase angle error between the voltage and the current signals for a channel with a pure resistive load. The initial value of this parameter is set to 0.

2.2.4 What is the recommended value for integration period parameter for the metrology engine initialization?

The recommended value of integration period parameter for the metrology engine is between 45 and 130 mains periods (inclusive).

2.2.5 What do the following members in metrology_result_t denote: vphigh, vplow, iphigh, iplow?

These fields indicate the maximum positive and negative peak values of the voltage and current signals during the last integration period. These values are used in the offset calibration.

1. **vphigh** – maximum positive peak of the input voltage signal.
2. **vplow** – maximum negative peak of the input voltage signal.
3. **iphigh** – maximum positive peak of the input current signal.
4. **iplow** – maximum negative peak of the input current signal.

2.2.6 What is metrology_offset_t structure used for?

The data supplied by the metrology_offset_t structure are used to compensate for the opamp input offset errors.

2.2.6.1 How are the values computed for the offset data supplied to the metrology engine software using the metrology_set_offsets API?

The detailed steps to determine the value of the offsets for all the voltage and current channels are listed in the section “Calibration of offsets” in the EM783 SDK user manual. vphigh, vplow, iphigh, iplow members of metrology_result_t are used for the offset calibration. Summary of the steps to determine the offsets is as follows:

1. Supply the voltage input from an AC source to the voltage input of EM783 EVM.
2. Observe the values of positive and negative voltage peaks.
3. If the value of positive peak is equal to the negative peak, offset value for the channel is 0.
4. If the value of positive and negative peak values are not equal, then the offset parameter is computed as follows:

$$Offset = -[(Vphigh + Vplow)/2] \tag{3}$$

5. Apply the offset and ensure that both positive and negative peaks have the same value.

2.2.7 What is the sampling frequency of the metrology engine?

Metrology engine samples at 6.4 ksps.

2.2.8 How does EM783 metrology engine select between the high-gain and low-gain channels?

EM783 metrology engine samples both the high-gain and low-gain channels simultaneously and combines the data to generate the metrology results for the current input.

2.2.8.1 Are external components such as relays required for the channel selection?

No external hardware components are required on the board to select between the high-gain and low-gain channels.

2.2.9 What is the shortest response time (time at which the measurement results are available) of the metrology engine?

The metrology engine integration duration is configurable from 45 to 130 mains periods. The metrology result is available only at the end of every integration period. Hence, the integration period is the shortest response time of the metrology engine.

For example: For 220 V/50 Hz mains system with integration period configured to 130 mains periods, the metrology results will be available every 2.6 s (130 * (1÷50)).

2.2.10 Does the accuracy of the metrology engine calibrated with 220 V/50 Hz mains remain intact when the system is used with 110 V/60 Hz mains?

No. The unit needs recalibration with 110 V/60 Hz mains input to achieve the desired accuracy.

2.3 SDK for EM783

2.3.1 Where can the EM783 SDK package be downloaded from?

EM783 SDK package can be downloaded from the EM783 support website.

2.3.2 What toolchains and debuggers does the EM783 SDK support?

EM783 1.0 EVM is tested with the following toolchain-debugger combinations:

Table 2. EM783 SDK toolchain list

Toolchain	Debugger
Keil uVision 4.60.0.0	ULINK2

2.4 Calibration

2.4.1 What is the procedure used to calibrate the metrology engine?

Refer to the calibration section of the EM783 SDK user manual available at the EM783 support website.

2.4.2 Does the metrology firmware require upgrading when the analog front end components are modified?

No. The metrology firmware need not be upgraded, if the analog frontend is re-designed for a different current range. The unit requires only recalibration.

2.5 Analog front end design

2.5.1 Why are two gain channels used for a single current input in MC3, SC and SP variants?

MC3, SC and SP variants of EM783 use two gain channels for a single current input to achieve the accuracy and the dynamic range listed in Table 1.

2.5.2 Does the phase of the voltage and current inputs require matching on the AFE?

No. The voltage and the current signal phases need not be matched by the AFE circuitry. Instead, the calibration procedure corrects for the phase difference between the two signals. Refer to the calibration section of the EM783 SDK user manual for more details on phase correction.

2.5.3 Why does the metrology engine report the active power as a negative quantity?

The active power is computed as a negative quantity, if:

1. The CT terminal connections to the AFE are reversed.
2. The direction of current flow from the source to the load through the CT is reversed.

2.5.4 How are the unused inputs of opamps connected?

For minimum opamp power consumption,

1. Connect the positive input of the opamp to VDD/2 through a resistive divider network (using two 1 MΩ resistors).
2. Tie the negative input of the opamp to the opamp output.

2.5.5 Does the burden resistor require specific placement?

Place the burden resistor as close to the opamp as possible. Also, ensure that the trace connecting the current transformer (CT) to the burden resistor is as short as possible.

2.5.6 What should be the upper limit on the board noise level to achieve the desired accuracy?

To meet the desired accuracy and dynamic range, the PCB noise level should not exceed 10 mV_{pp}.

2.5.7 Does the opamp feedback components require specific placement?

Place the opamp feedback components as close to the opamps as possible.

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Notes

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Date of release: 17 December 2013

Document identifier: UM10756